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Brochman

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(54) **CONDUIT BENDER**

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(22) Filed: **Sep. 10, 2019**

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(51) **Int. Cl.**
B21D 7/06 (2006.01)

(52) **U.S. Cl.**
CPC ***B21D 7/06*** (2013.01)

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CPC B21D 7/02; B21D 7/022; B21D 7/024; B21D 7/06; B21D 7/063; B21D 7/08
See application file for complete search history.

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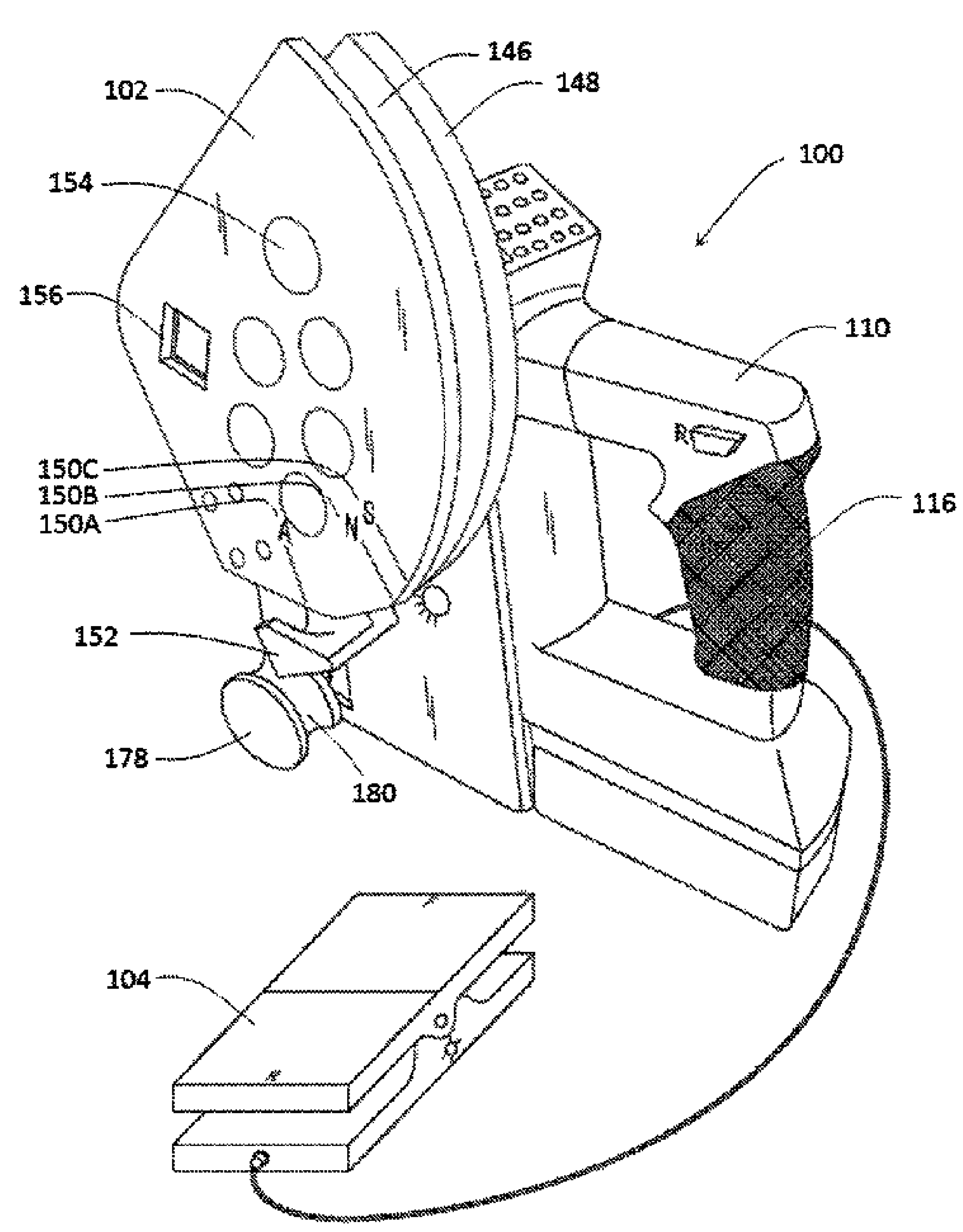
(57) **ABSTRACT**

A portable, self-contained conduit bender having a housing configured to house a reductive gear set, thereby improving safety and extending the life of the conduit bender by limiting exposure of the reductive gear set to dust and debris. The conduit bender includes a motor configured to drive a driven shaft at a first rotational output, a reductive gear set operably coupling the driven shaft to an output shaft, the reductive gear set configured to reduce the first rotational output of the driven shaft to a second rotational output of the output shaft, a housing defining an interior cavity configured to house the reductive gear set, such that only a portion of the output shaft emerges from the interior cavity, and a bender shoe coupleable to the output shaft, the bender shoe defining an arcuate channel configured to receive conduit during bending operations.

17 Claims, 14 Drawing Sheets



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Application and File history for U.S. Appl. No. 16/247,211, filed Jan. 14, 2019. Inventors: Brochman.

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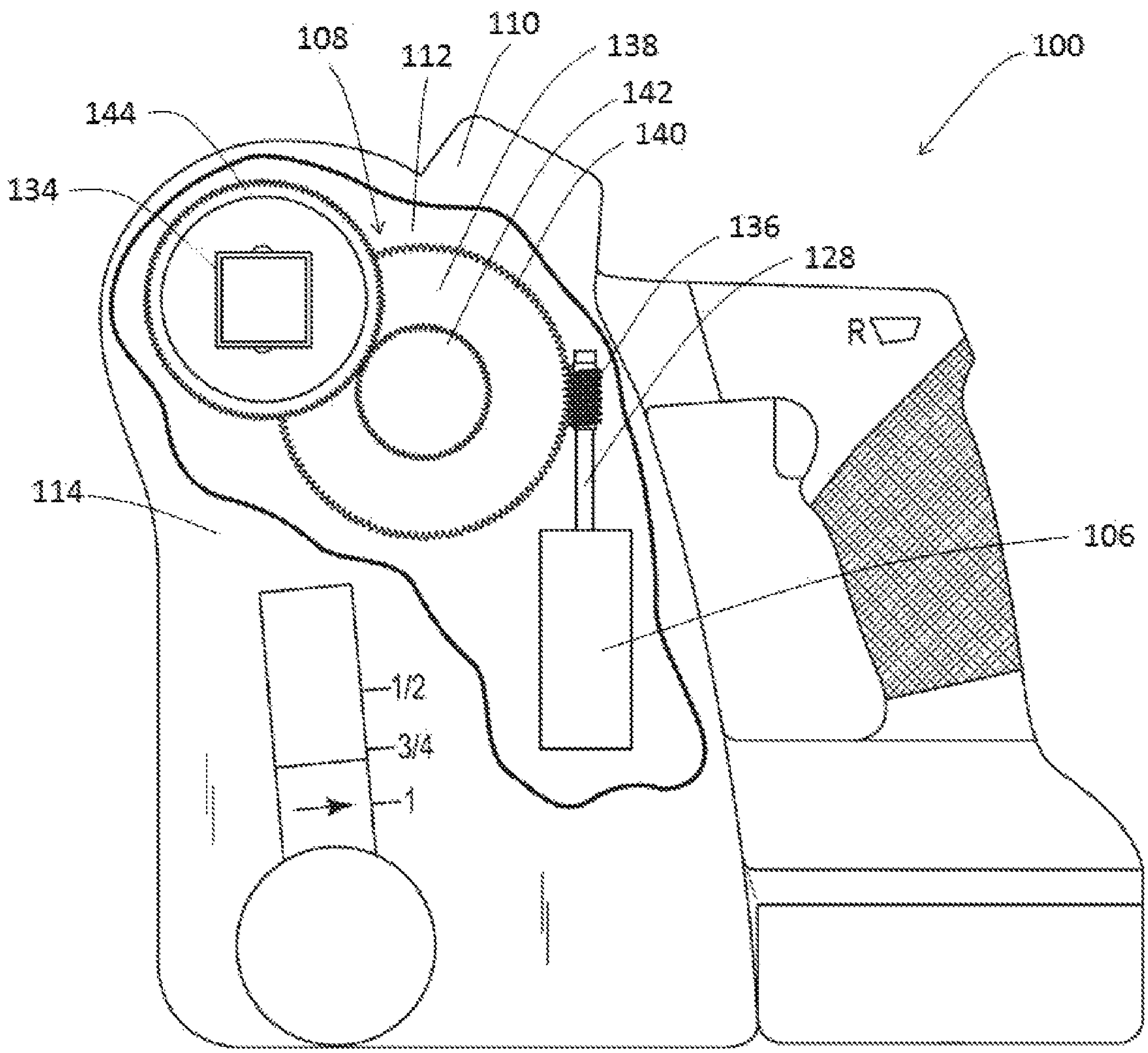

FIG. 1

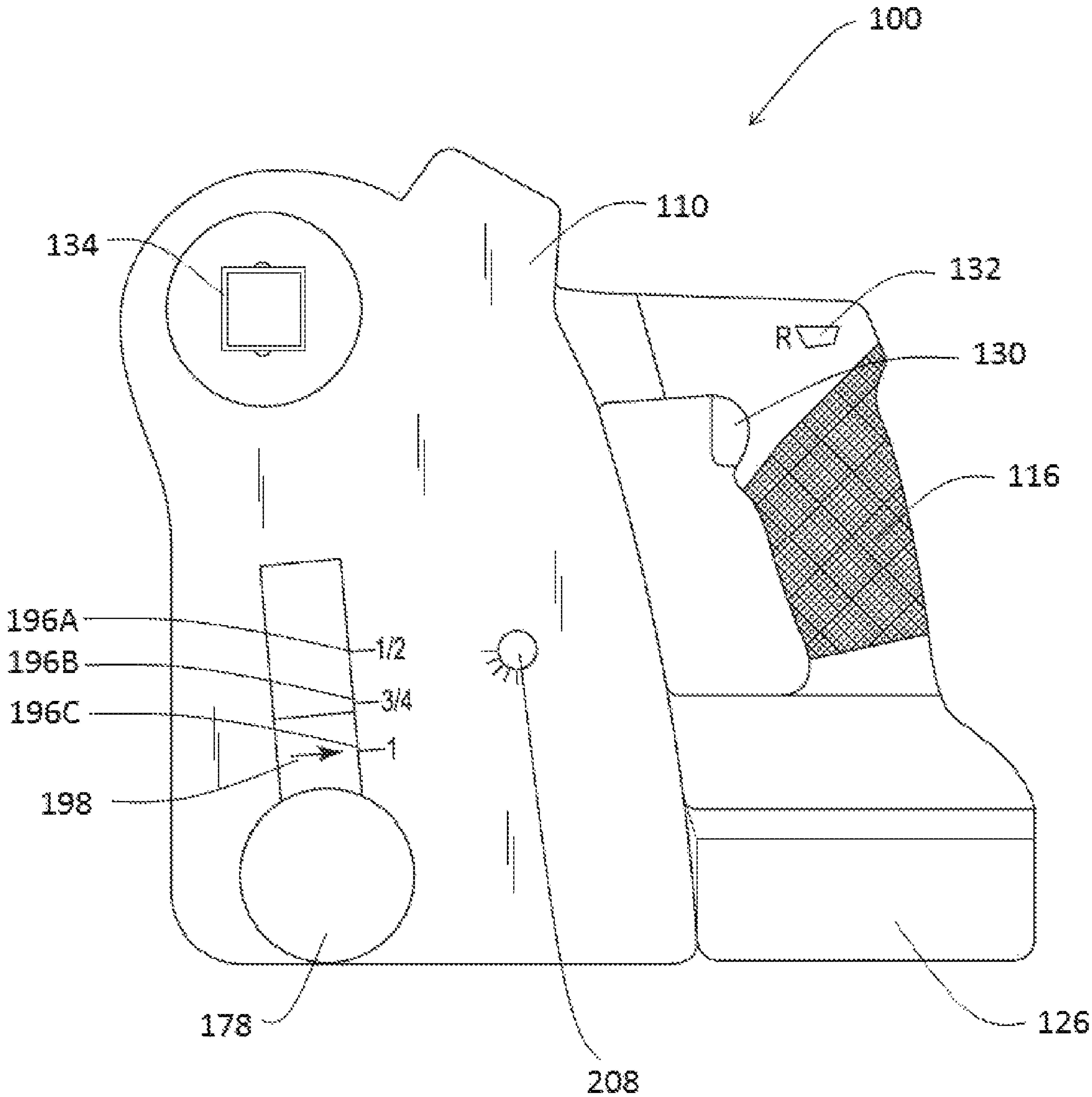

FIG. 2A

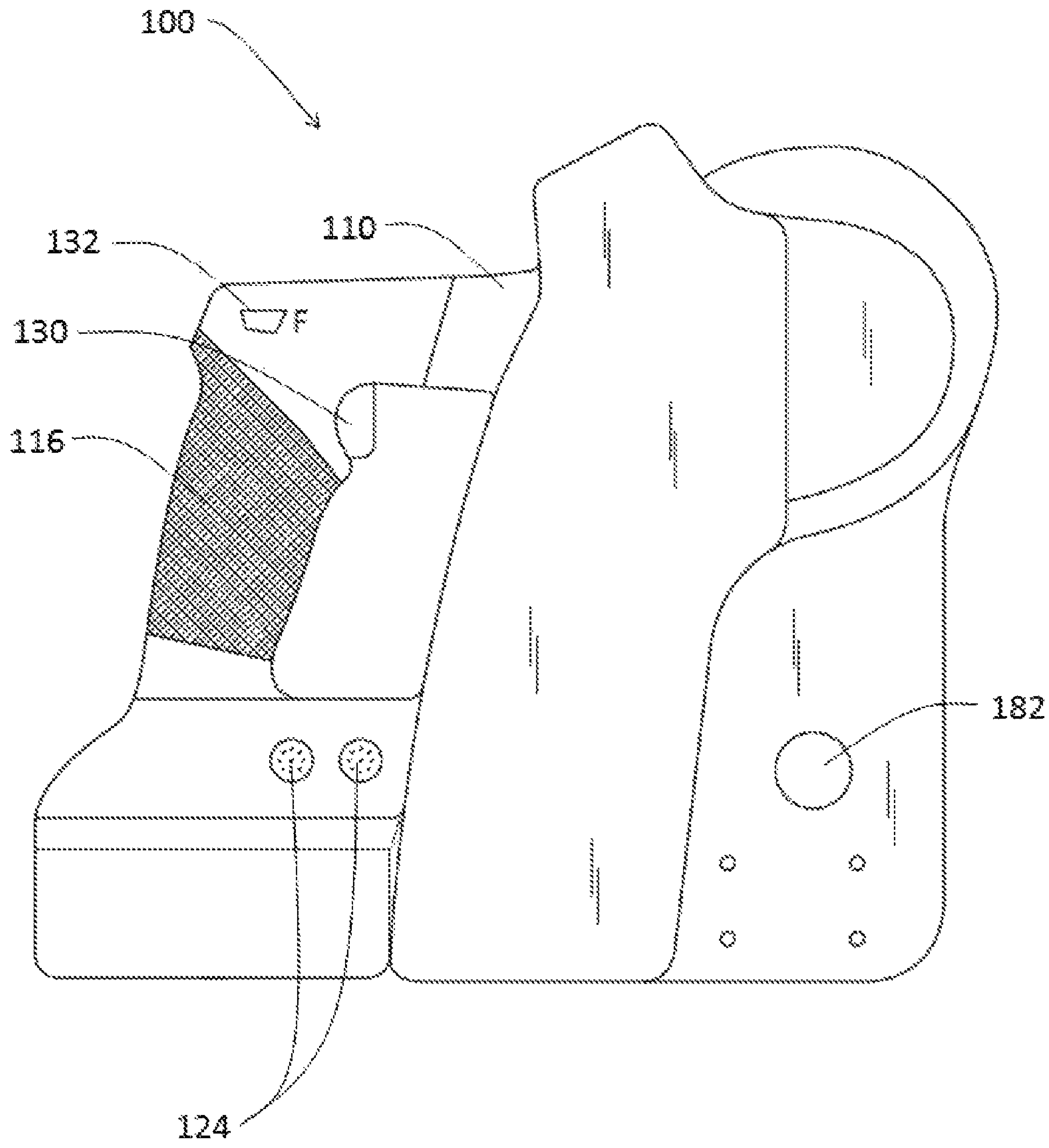

FIG. 2B

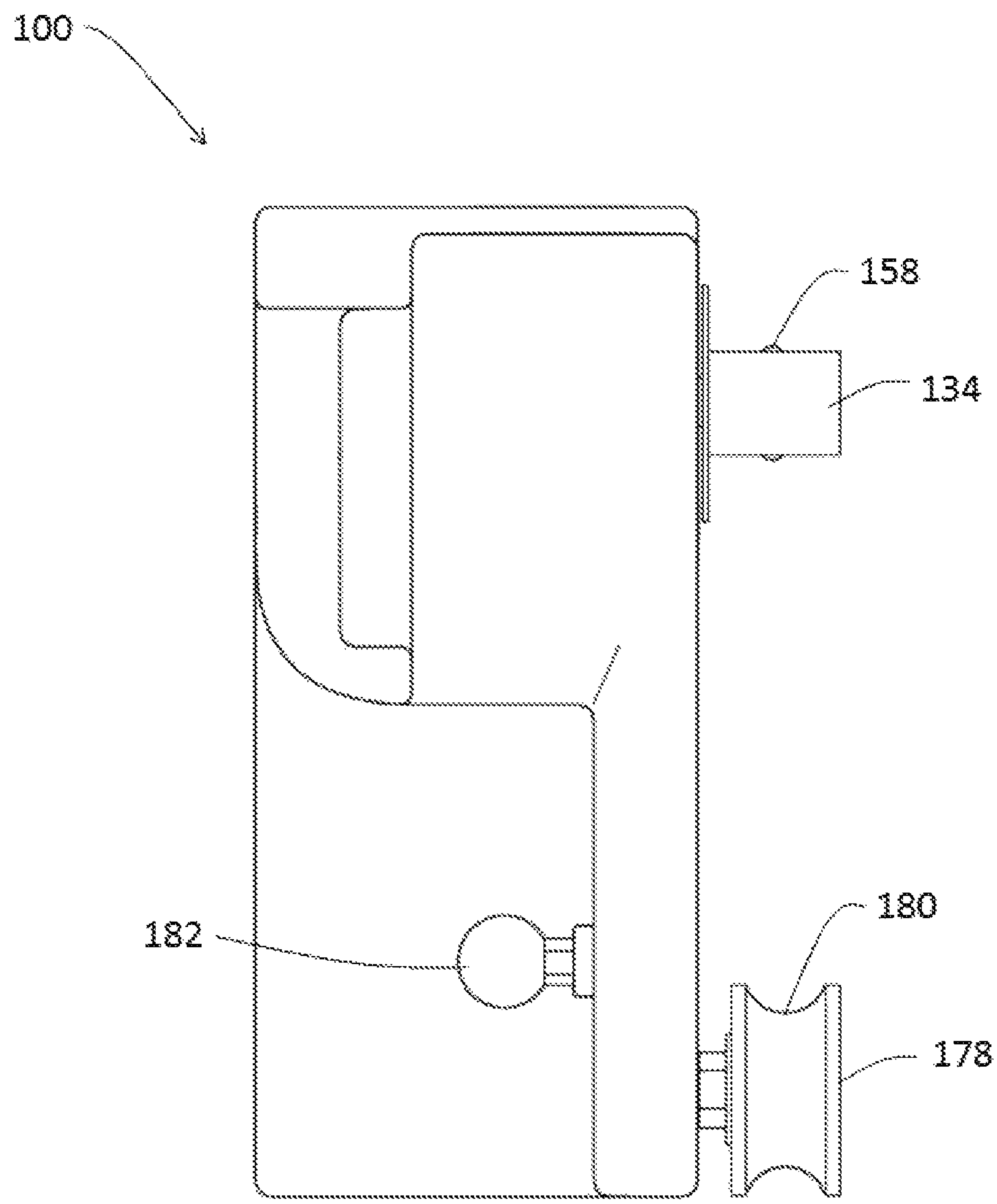

FIG. 2C

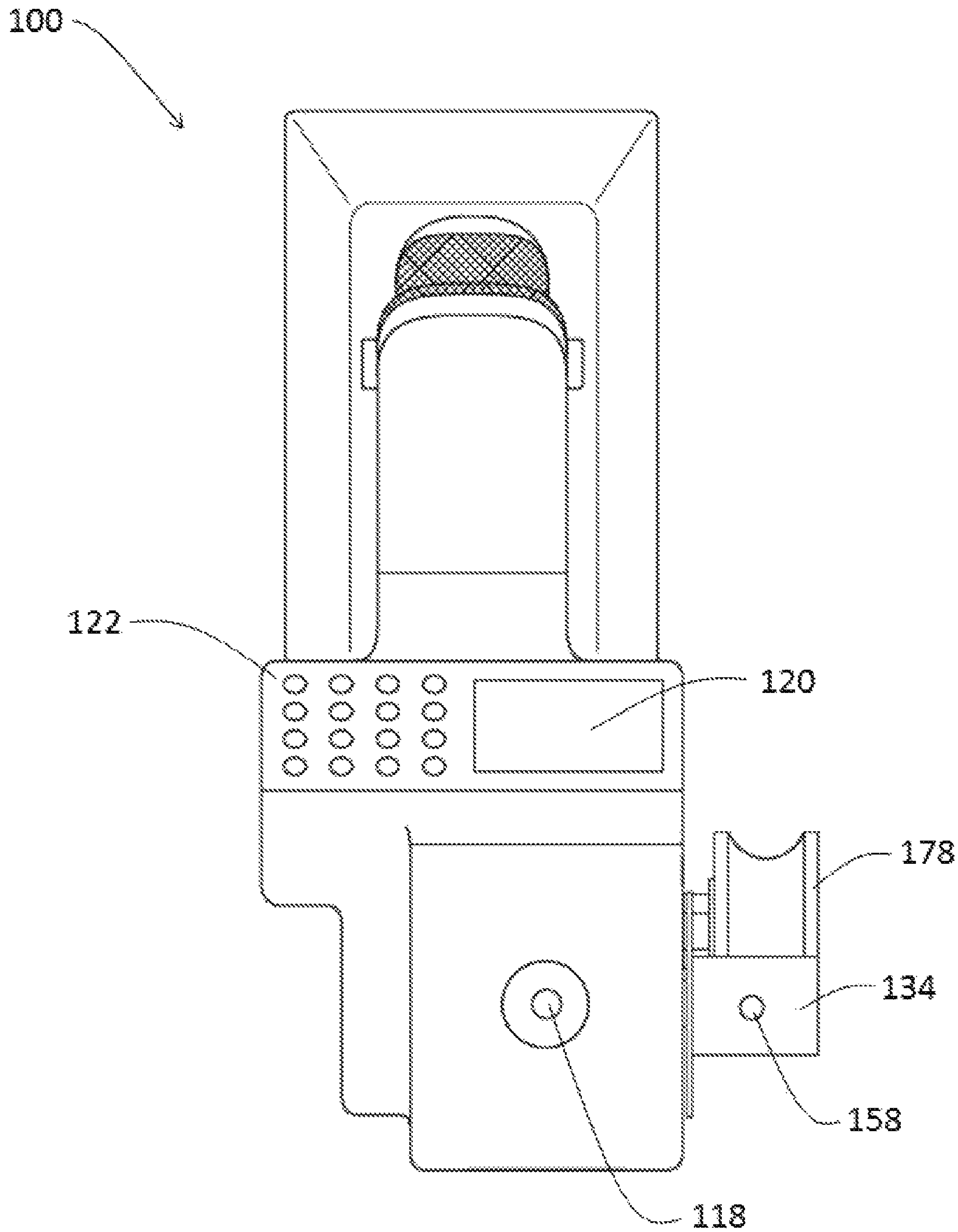

FIG. 2D

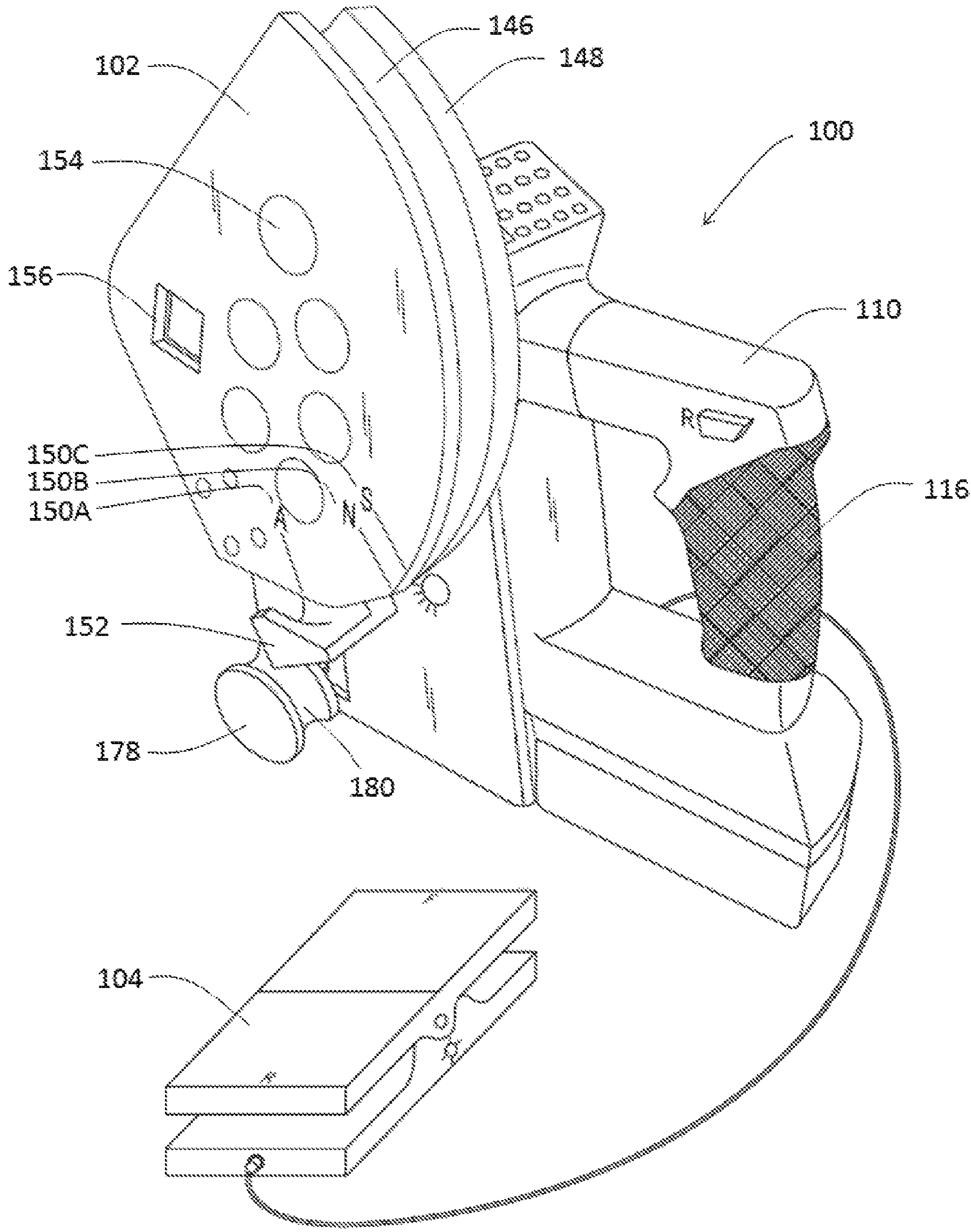
146
148
102
100
154
156
110
R
150C
150B
150A
S
N
A
116
152
178
180
104

FIG. 3A

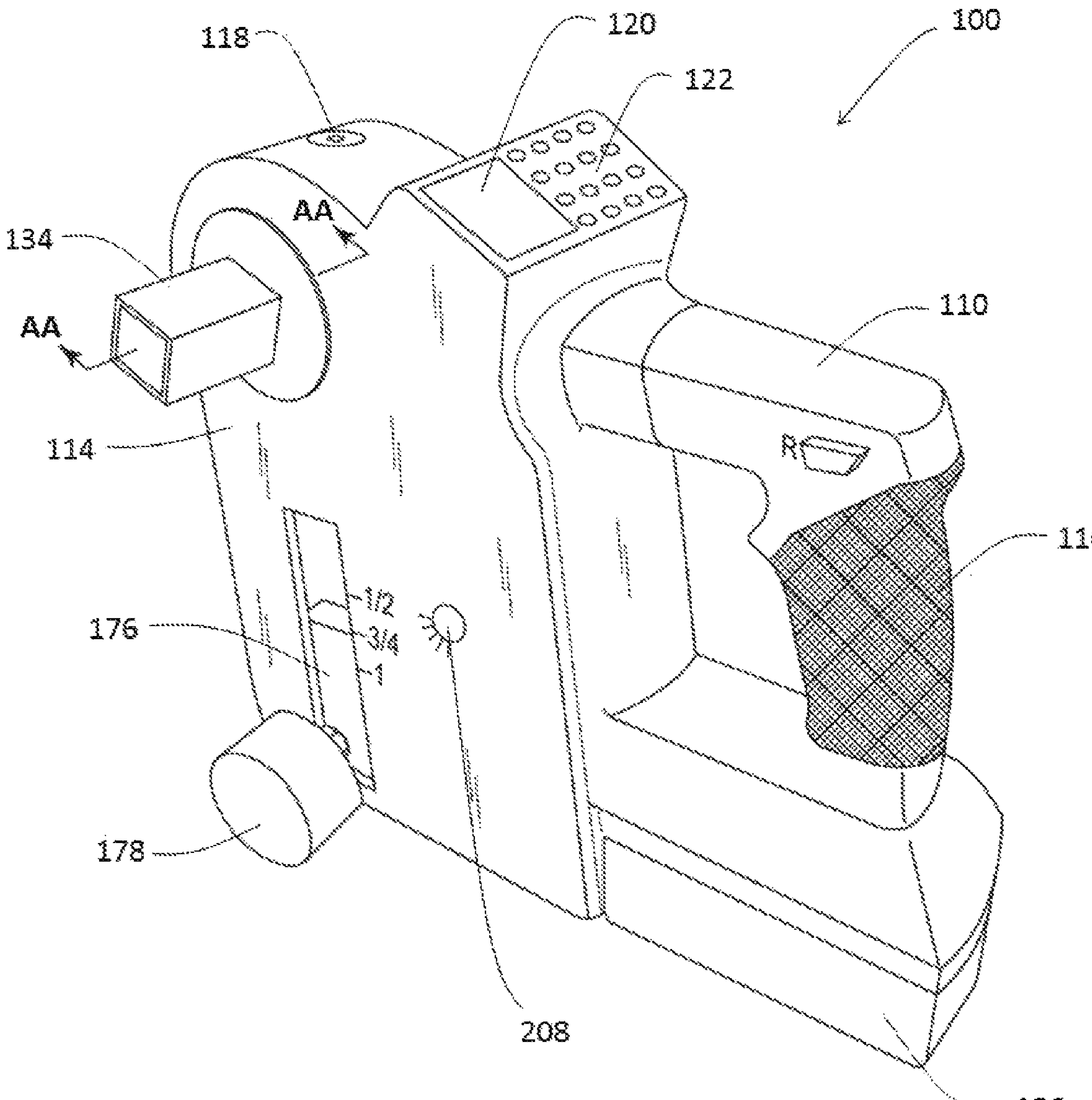

FIG. 3B

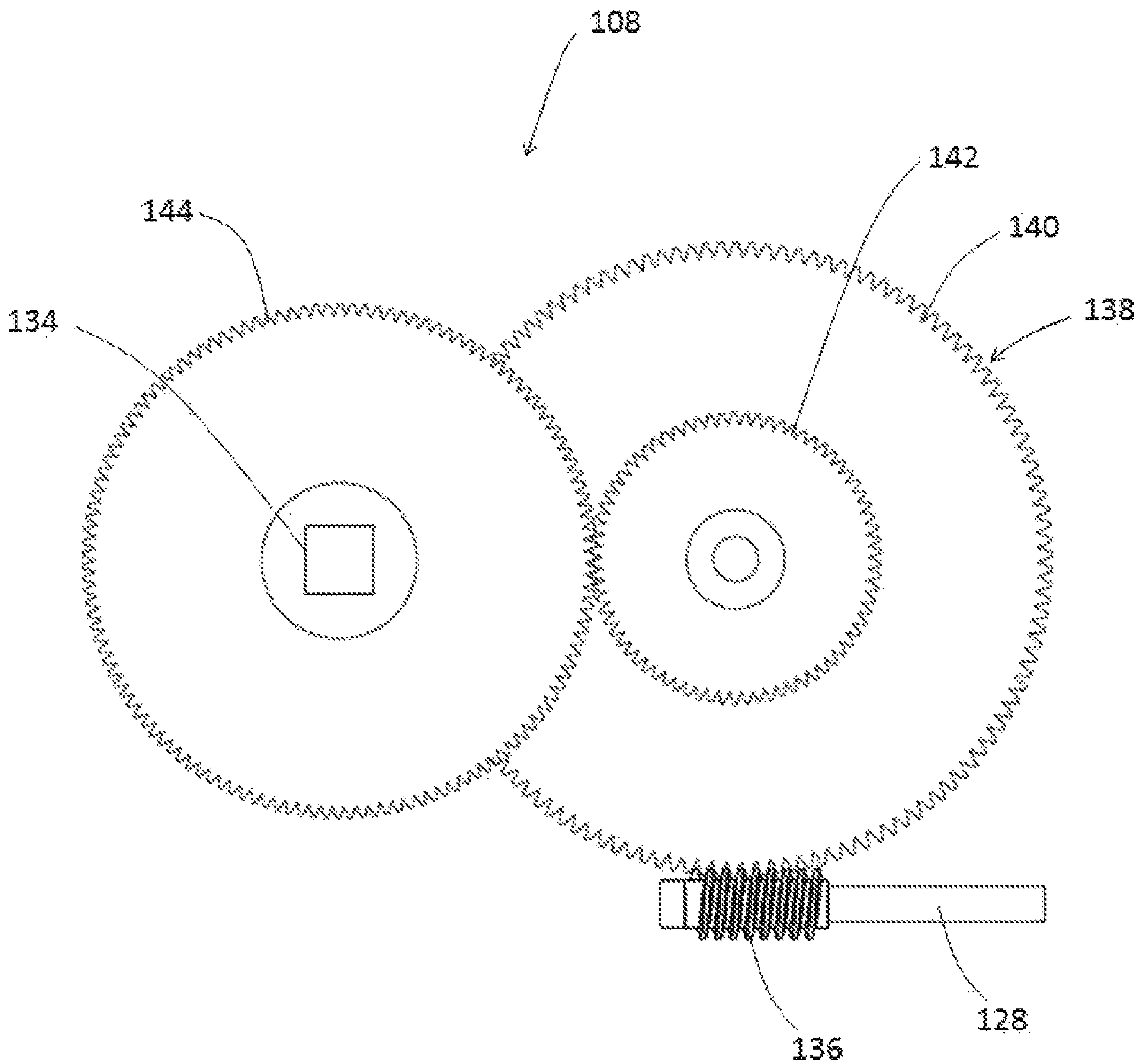

FIG. 4

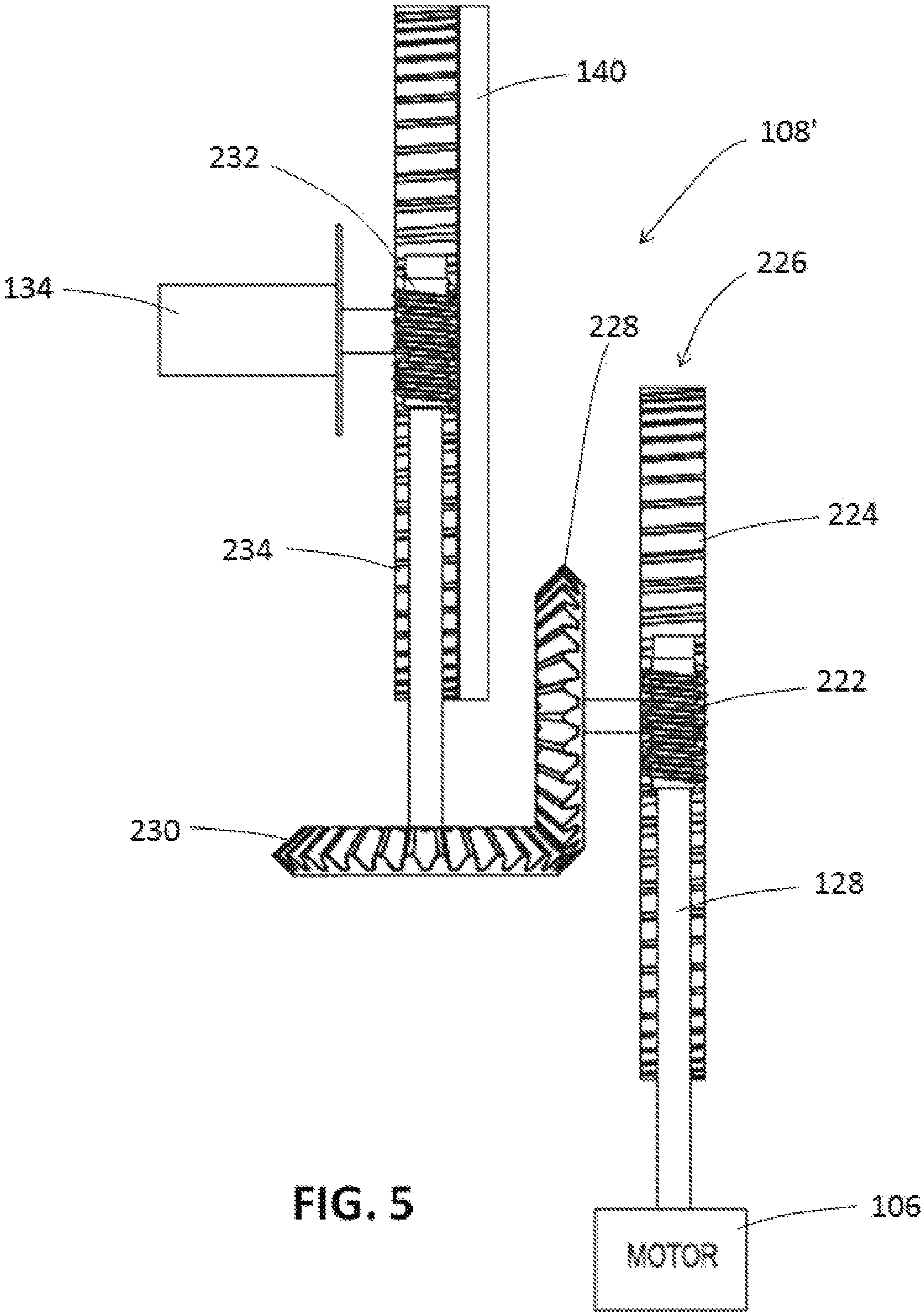

FIG. 5

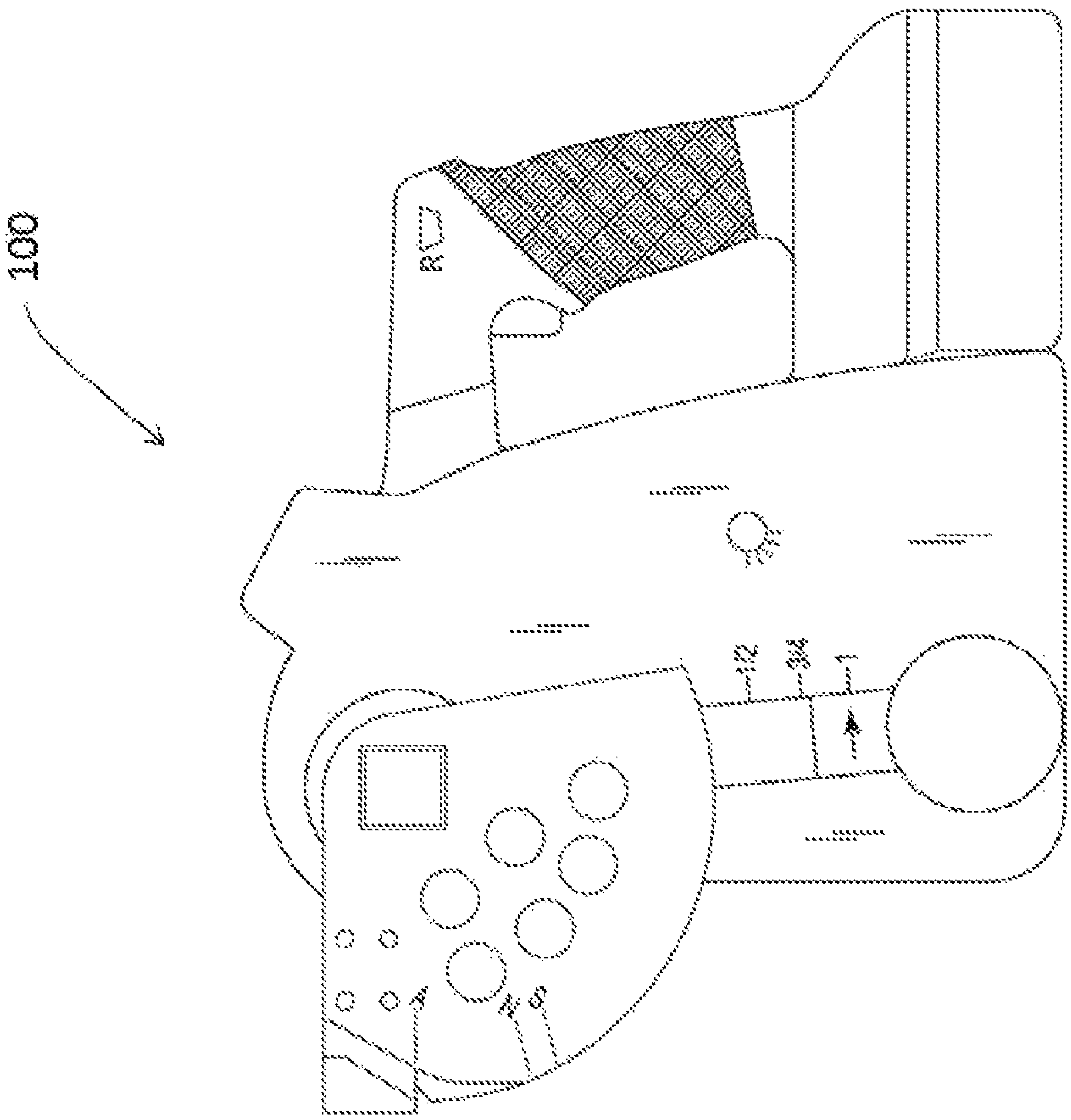

FIG. 6B

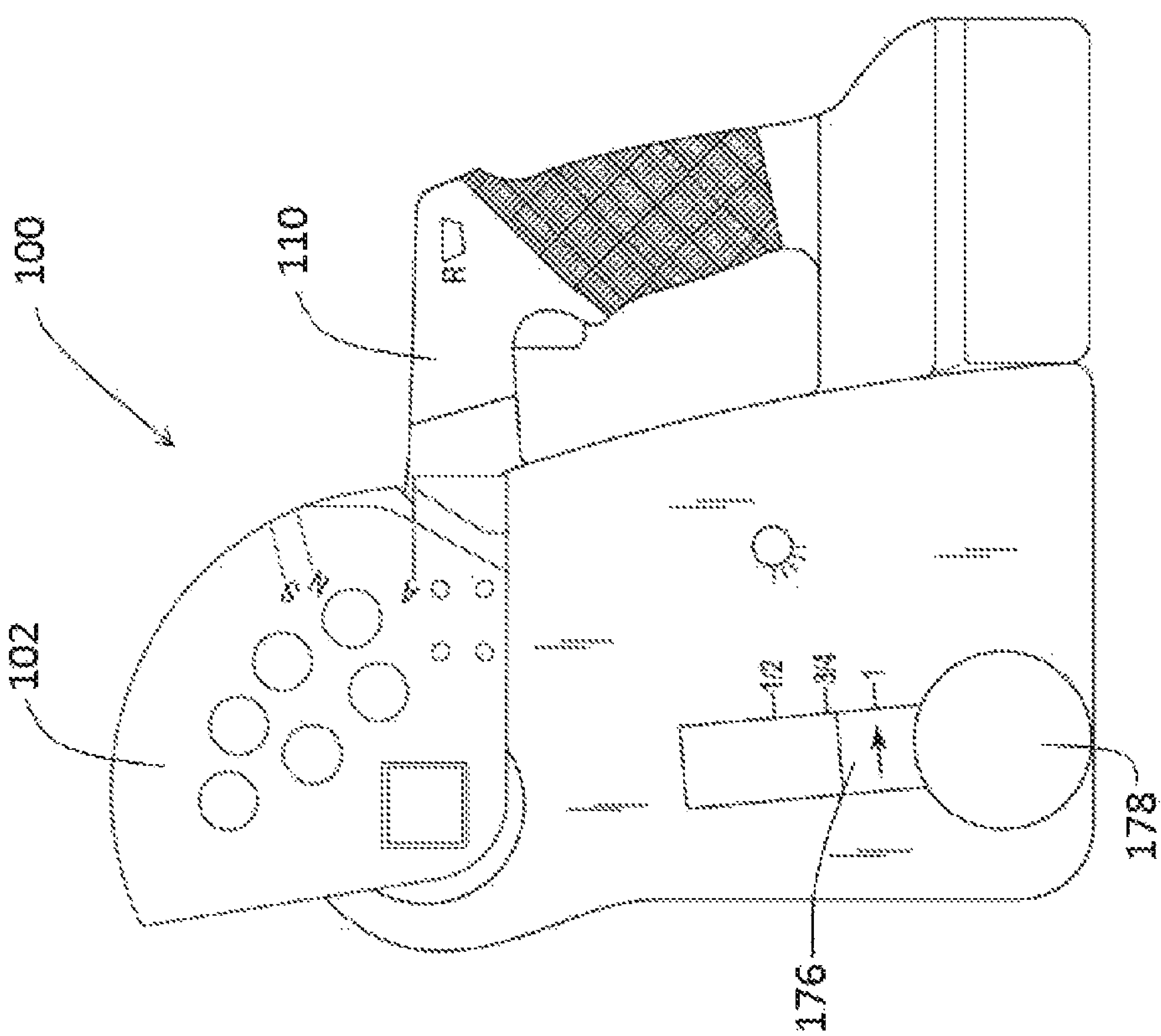

FIG. 6A

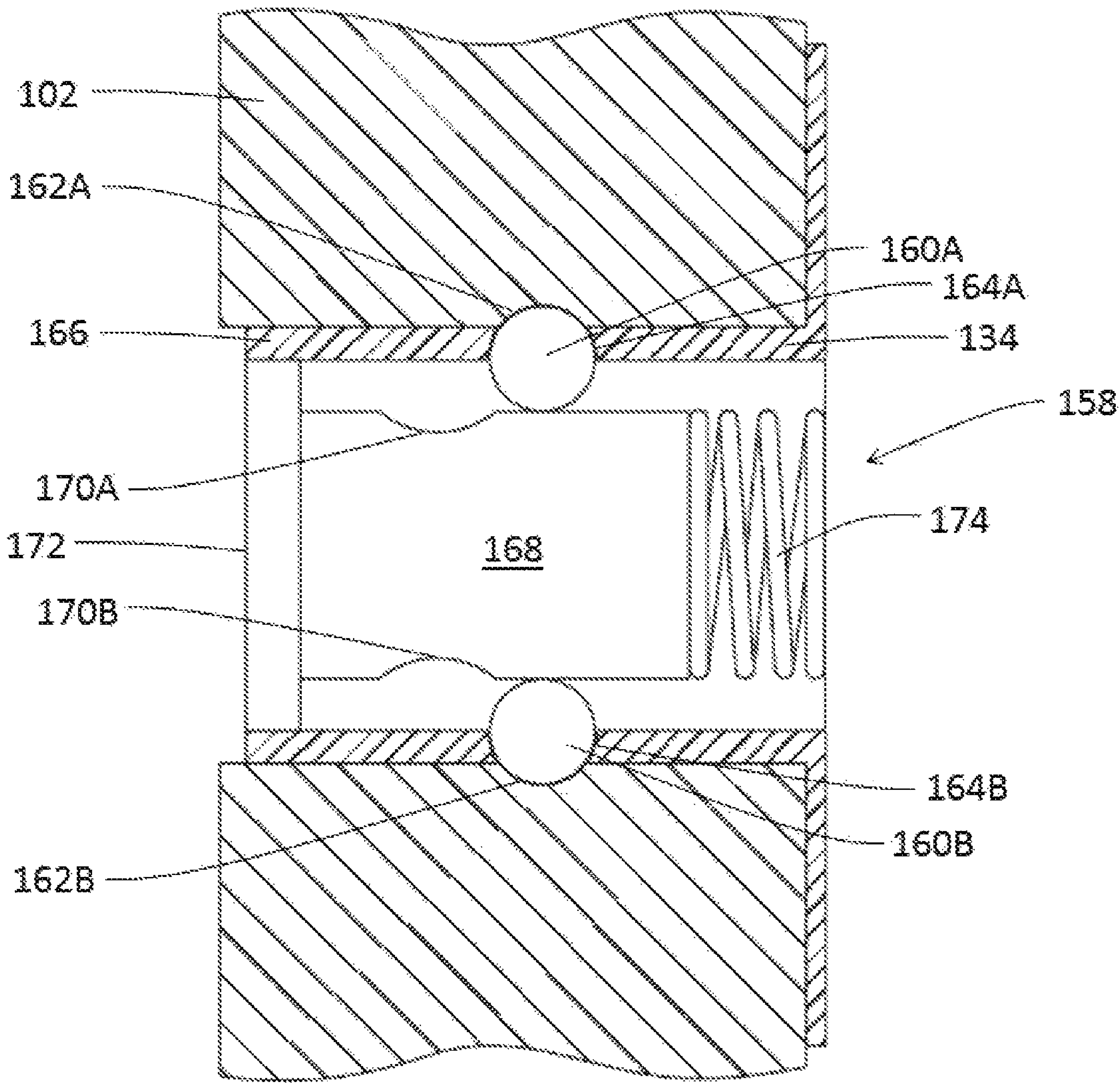

FIG. 7
(Section AA)

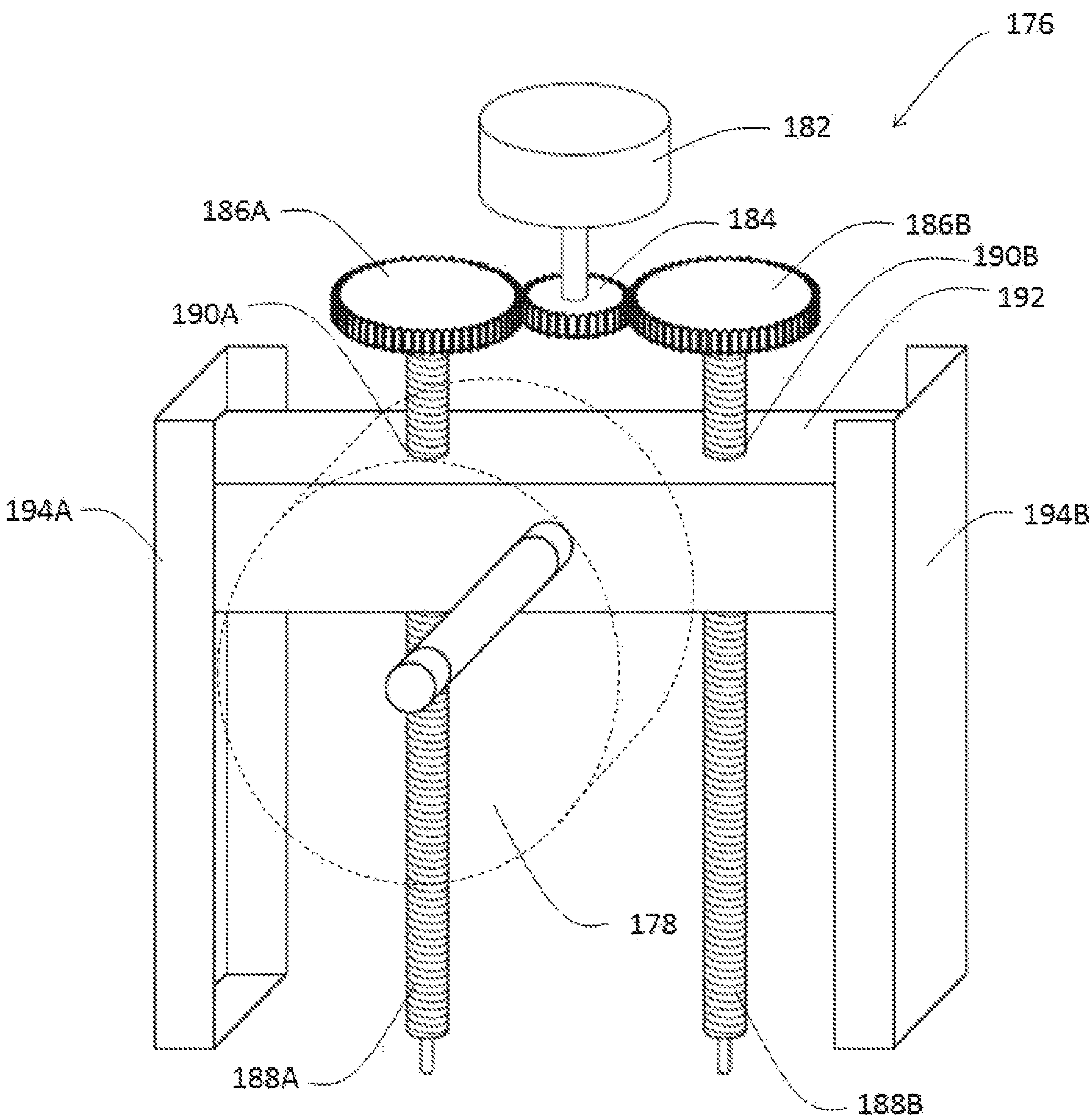

FIG. 8

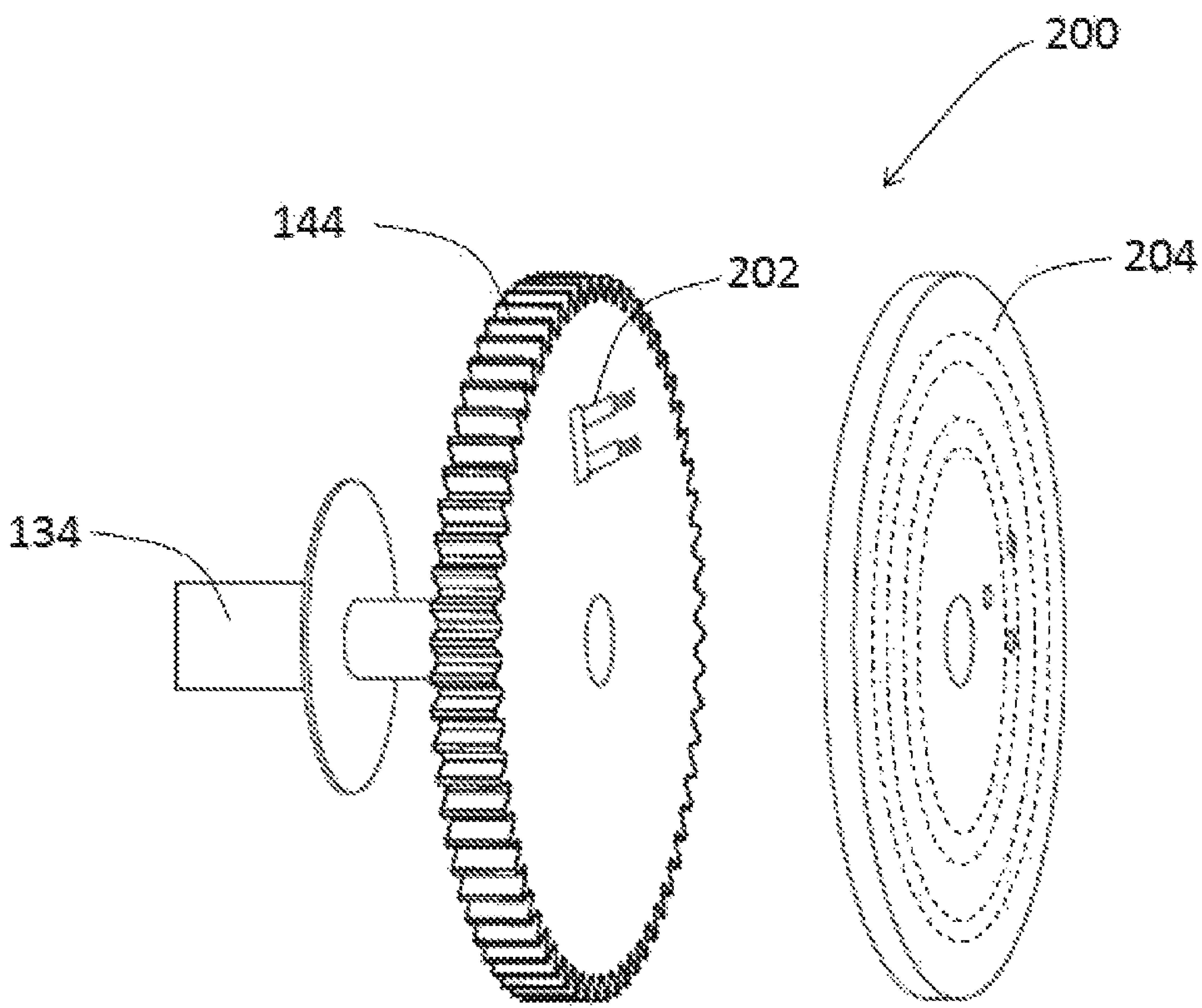

FIG. 9A

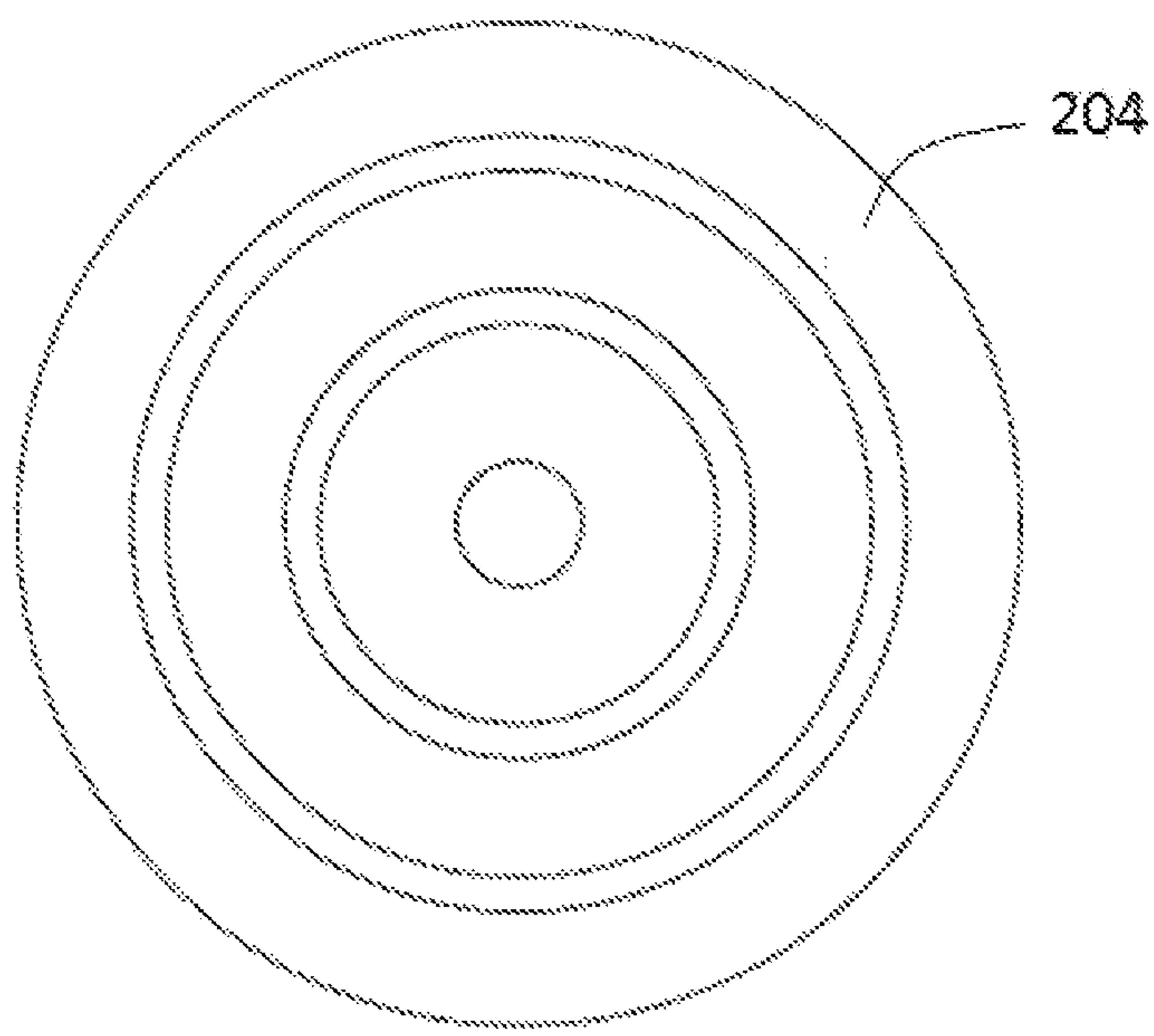

FIG. 9B

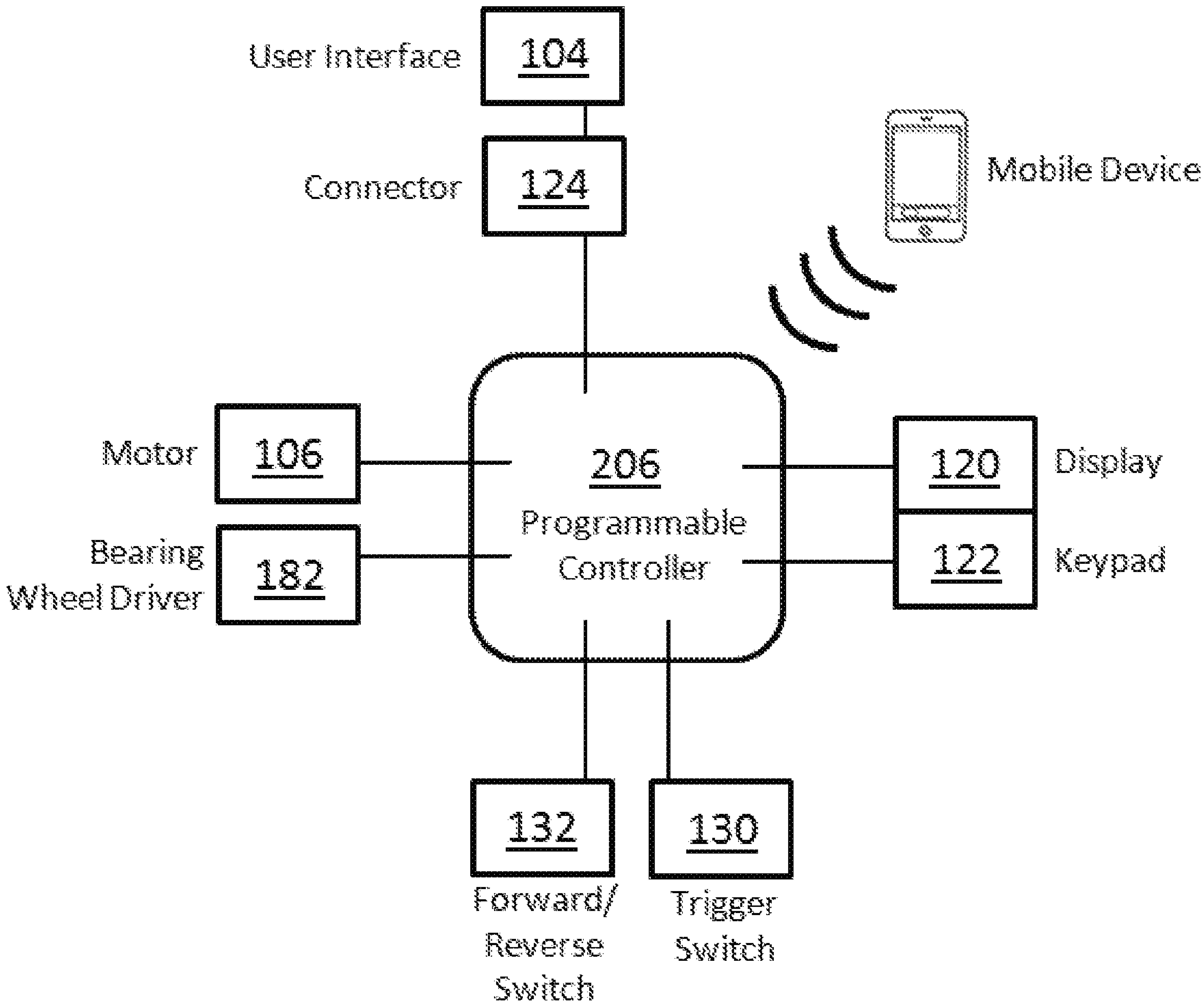
User Interface
104
Connector
124
Mobile Device
Motor
106
Bearing
Wheel Driver
182
206
Programmable
Controller
120
Display
122
Keypad
132
Forward/
Reverse
Switch
130
Trigger
Switch

FIG. 10

CONDUIT BENDER

RELATED APPLICATION

This application is a continuation of application Ser. No. 16/247,211 filed Jan. 14, 2019, which is hereby fully incorporated herein by reference.

TECHNICAL FIELD

The present disclosure relates generally to conduit benders, and more particularly to portable, self-contained conduit benders.

BACKGROUND

Electrical conduit is a thin-walled tubing used to protect and route electrical wiring in a building or structure. Electrical conduit, often in the form of Electrical Metallic Tubing (EMT), is constructed of straight elongated sections of corrosion resistant galvanized steel of about 10 feet in length, with a diameter of between about ½ and 4 inches. For example, EMT with standard trade size designations of ½ inch, ¾ inch, 1 inch, and 1¼ inch are commonly installed by electricians at the site of installation of electrical equipment, and in compliance with the U.S. National Electric Code (NEC) and other building codes.

Prior to installation, it is often necessary to bend the conduit. This can be accomplished with a manually operated tool known as a conduit bender, which provides a desired bend in the conduit without collapsing the conduit walls. A typical conduit bender includes a handle and a head. The head is generally a one-piece construction, including an arcuate shoe with a lateral concave channel for supporting the conduit. A hook is generally formed into the head proximate to one end of the channel for engaging a portion of conduit received in the channel. The handle, which is generally about 2 to 3 feet long, is secured to the head and is generally positioned in a radial line relative to the arcuate shoe. Such manually operated conduit benders are commonly produced by companies such as Benfield Electric Co., Gardner Bender, Greenlee Tools, Ideal Industries, Klein Tools, and NSI Industries, among others.

To bend the conduit, a length of conduit is positioned on a supporting surface, such as the ground, with a portion of the conduit positioned within the channel of the arcuate shoe, such that the hook of the conduit bender engages the conduit. The handle is then forced to roll the shoe onto the conduit, thereby bending the conduit to fill in the arcuate channel. Accordingly, the use of a manually operated conduit bender requires a stable work surface, as well as space sufficient to manipulate the handle relative to the conduit. For larger size conduit, such as EMT with a designated standard size of a 1 inch or greater, the bending may be assisted by an electric, hydraulic or pneumatic motor. Various heavy-duty wheeled or bench mounted benders are produced by companies such as Greenlee Tools, among others.

Frequently installations require the conduit to be routed along the ceiling or parts of a building structure that are normally out of reach when standing on the ground. In such instances, it is common to utilize a lift, frequently referred to as a "cherry picker," to safely access the intended conduit route. However, given the limited size of the platform or basket of most lifts, and the lack of a stable horizontal work surface, it is difficult to operate a manual conduit bender while using the lift. Accordingly, most electricians bend the conduit on the ground before loading the conduit onto the lift and ascending to the installation location. If it is determined that additional bending is required, the electrician must then descend back to the ground to conduct the additional bending. In some instances, multiple ascents and descents are required to complete the electrical routing, all of which can significantly add to the time and expense of the electrical conduit installation. Further, in some instances, the electrician may be working with multiple conduit diameters, each of which requires its own specific tool to complete the desired bends.

Recent advances in conduit bending have seen an introduction of portable powered conduit benders. Various examples of such powered benders are disclosed in U.S. Pat. Nos. 7,900,495; 9,718,108 and U.S. Patent Publication No. 2009/0188291, assigned to Husky Tools, Inc. Another example of a bending apparatus is disclosed in U.S. Patent Publication No. 2008/0190164. The aforementioned disclosures are hereby incorporated by reference herein to the extent that they do not contradict teachings of the present disclosure.

Although these benders are satisfactory for their intended purpose, all include a single large exposed, single stage gear drive, which makes the bender both bulky and invites the possibility of injury, as the gear drive includes a pinch point which can bite the user or grab an article of clothing, such as a shirtsleeve, neck lanyard or safety vest. Further, exposure of the drive gear invites the possibility of inadvertent introduction of foreign matter between the gears, which can permanently damage the bender, thereby decreasing its usable life. The present disclosure addresses these concerns.

SUMMARY OF THE DISCLOSURE

Embodiments of the present disclosure provide a portable, self-contained conduit bender having a housing configured to house a reductive gear set and motor. Accordingly, the housing is configured to improve user safety by acting as a shield to inhibit inadvertent contact with pinch points, rapidly rotating members and other potentially hazardous mechanical components of the conduit bender, and to extend the life of the conduit bender by limiting exposure of the reductive gear set and motor to dust and debris common in the work environment. Further, in some embodiments, a compound reductive gear set can be utilized to provide a more compact construction. In one embodiment, the compound reductive gear set can include at least one gear in contact with two other gears, Such contact can include fixed coupling of the rotational axis of at least one gear to the rotational axis of another gear. In one embodiment, the compound reductive gear set can for example employ a train of at least three gears.

One embodiment of the present disclosure provides a portable, self-contained conduit bender including a motor, reductive gear set, housing, and bender shoe. The motor can be configured to drive a driven shaft at a first rotational output. The reductive gear set can operably couple the driven shaft to an output shaft. The reductive gear set can be configured to reduce the first rotational output of the driven shaft to a second rotational output of the output shaft. The housing can define an interior cavity configured to house the reductive gear set, such that only a portion of the output shaft emerges from the interior cavity. The bender shoe can be coupleable to the output shaft, and can define an arcuate channel configured to receive conduit during bending operations.

In one embodiment, the arcuate channel of the bender shoe can be configured to receive at least one of Electrical Metallic Tubing (EMT), Rigid Metal Conduit (RMC), Intermediate Metal Conduit (IMC), stainless steel tubing, copper tubing, tubing used for HVAC or refrigeration systems, tubing used in elevator systems, and other types of tubing or conduit. In one embodiment, the output shaft can include a quick release configured to enable ease in interchangeability and detachability in the coupling of any of two or more bender shoes to the output shaft.

In one embodiment, the conduit bender can further include a bearing wheel configured to guide and support conduit during bending operations. In one embodiment, the bearing wheel can be driven by an actuation motor to a desired distance from the output shaft to accommodate conduit of varying sizes. In one embodiment, the conduit bender can include a built-in level configured to aid in leveling the conduit bender relative to a gravitational frame of reference along at least x-axis and y-axis. In one embodiment, the motor can be at least one of electrically, hydraulically, or pneumatically powered.

In one embodiment, the conduit bender can include a sensor configured to sense an angular position of the bender shoe relative to the housing. In one embodiment, the conduit bender can include a display configured to display a digital readout of an angular position of the bender shoe. In one embodiment, the display can further include a user interface configured to accept input from a user. In one embodiment, the user interface can be configured to accept a desired angular position of the bender shoe relative to the housing. In one embodiment, the conduit bender can include a programmable controller configured to automatically cease operation of the motor upon reaching the desired angular position as determined by the sensor. In one embodiment, the conduit bender can further include a worklight configured to illuminate a portion of conduit in proximity to the bender shoe during bending operations.

Another embodiment of the present disclosure provides a conduit bender including a motor, reductive gear set, housing, and bender shoe. The motor can be configured to drive a driven shaft at a first rotational output. The reductive gear set can operably couple the driven shaft to an output shaft. The reductive gear set can be configured to reduce the first rotational output of the driven shaft to a second rotational output of the output shaft. The housing can define a handgrip enabling user manipulation of the conduit bender, and an interior cavity configured to house the reductive gear set, such that only a portion of the output shaft extends to an exterior of the housing. The bender shoe can be coupleable to the output shaft.

Another embodiment of the present disclosure provides a method of constructing a conduit bender, including: forming a housing defining an interior cavity and a handgrip; positioning a motor configured to rotationally drive a driven shaft within the interior cavity; positioning a reductive gear set configured to operably couple the driven shaft to an output shaft within the interior cavity, such that only a portion of the output shaft emerges from the interior cavity; and forming a bender shoe coupleable to the output shaft.

Another embodiment of the present disclosure provides a portable conduit bender including a motor, a reductive gear set, a bender shoe, and an actuatable bearing wheel. The motor can be configured to rotationally drive a driven shaft. The reductive gear set can operably couple the driven shaft to an output shaft. The bender shoe can be coupleable to the output shaft, and can define an arcuate channel configured to receive conduit during bending operations. The actuatable bearing wheel can be configured to be driven by an actuation motor to a desired distance from the output shaft to accommodate conduit of varying sizes.

In one embodiment, the conduit bender can further include a user interface configured to accept input from the user. In one embodiment, the user interface can be configured to enable manual adjustment of the actuatable bearing wheel via the actuation motor. In one embodiment, the user interface can be configured to accept a desired conduit size, such that during bending operations a programmable controller operably coupled to the user interface automatically drives the actuatable bearing wheel to the desired distance from the output shaft via the actuation motor based on the accepted desired conduit size. In one embodiment, the user interface can be configured to accept a desired conduit bend angle, such that upon activation of the motor a programmable controller operably coupled to the user interface can automatically cease power to the motor upon bending conduit to the desired angle. In one embodiment, the programmable controller can further be configured to automatically drive the actuatable bearing wheel from an initial position to the desired distance from the output shaft via the actuation motor prior to commencing bending operations, and return the actuatable bearing wheel to the initial position via the actuation motor upon ceasing power to the motor.

The summary above is not intended to describe each illustrated embodiment or every implementation of the present disclosure. The figures and the detailed description that follow more particularly exemplify these embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosure can be more completely understood in consideration of the following detailed description of various embodiments of the disclosure, in connection with the accompanying drawings, in which:

FIG. **1** is a partial cutaway left side profile view depicting a conduit bender having components internal to a housing of the conduit bender, in accordance with an embodiment of the disclosure.

FIG. **2**A is a left side profile view depicting a conduit bender in accordance with an embodiment of the disclosure.

FIG. **2**B is a right side profile view depicting the conduit bender of FIG. **2**A.

FIG. **2**C is a front profile view depicting the conduit bender of FIG. **2**A.

FIG. **2**D is a top plan view depicting the conduit bender of FIG. **2**A.

FIG. **3**A is a perspective view depicting a conduit bender having a bender shoe and a remote user interface, in accordance with an embodiment of the disclosure.

FIG. **3**B is a perspective view depicting a conduit bender without a bender shoe attached, in accordance with an embodiment of the disclosure.

FIG. **4** is a schematic view depicting a compound reductive gear set, in accordance with a first embodiment of the disclosure.

FIG. **5** is a schematic view depicting a compound reductive gear set, in accordance with a second embodiment of the disclosure.

FIG. **6**A is a left side plan view depicting a conduit bender having a bender shoe rotated to a first position, in accordance with an embodiment of the disclosure.

FIG. **6**B is a left side plan view of the conduit bender of FIG. **6**B, with the bender shoe rotated to a second position.

FIG. **7** is a partial cross sectional view depicting a quick release mechanism of the conduit bender of FIG. **1**.

FIG. **8** is a schematic view depicting a bearing wheel assembly, in accordance with an embodiment of the disclosure.

FIG. **9**A is a schematic view depicting a sensor for a conduit bender, in accordance with an embodiment of the disclosure.

FIG. **9**B is a plan view depicting a portion of the sensor of FIG. **9**A.

FIG. **10** is a schematic view depicting a programmable controller for a conduit bender, in accordance with an embodiment of the disclosure.

While embodiments of the disclosure are amenable to various modifications and alternative forms, specifics thereof shown by way of example in the drawings will be described in detail. It should be understood, however, that the intention is not to limit the disclosure to the particular embodiments described. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the subject matter as defined by the claims.

DETAILED DESCRIPTION

Referring to FIG. **1**, a portable conduit bender **100** is depicted in accordance with an embodiment of the disclosure. The portable conduit bender **100** can be configured to enable a user to bend conduit, such as Electrical Metallic Tubing (EMT), Rigid Metal Conduit (RMC), Intermediate Metal Conduit (IMC), copper tubing, tubing used for HVAC or refrigeration systems, or tubing used in elevator systems, or other types of tubing or conduit, in a confined area, such as the platform of a lift or other limited workspace. The portable conduit bender **100** can be configured to bend conduit of a number of standard trade size designations (e.g., ⅜ inch, ½ inch, ¾ inch, 1 inch, 1¼ inch, 1½ inch, 2 inch, 2½ inch, 3 inch, 3½ inch, 4 inch, etc.), or generally conduit having a diameter of between about ⅜ inch (9.5 mm) and about 4 inches (101.6 mm). The portable conduit bender **100** can be configured to bend the conduit through a range of angles between about 0° and about 180° over a time span of up to about 60 seconds, depending upon the bend angle desired.

In one embodiment, the conduit bender **100** can be self-contained, such that a motor **106** and at least a portion of a reductive gear set **108** reside within a protective housing **110**. Accordingly, the housing **110** can define an interior cavity **112** configured to house at least a portion of the reductive gear set **108**, such that only a portion of the reductive gear set **108** emerges from the cavity **112** to extend to an exterior surface **114** of the housing **110**, thereby improving user safety by shielding drive system pinch points and rotating components which can bite the user or grab an article of clothing, as well as to extend the life of the conduit bender **100** by limiting exposure of the reductive gear set **108** and motor **106** to foreign articles, such as dust and debris.

With additional reference to FIGS. **2**A-D, which respectively depict a left side profile, right side profile, front, and top views of a portable bender **100**, in accordance with an embodiment of the disclosure, the housing **110** can be constructed of a rigid or semi rigid material, such as plastics, fiberglass, composites, or lightweight metals, such as aluminum or magnesium. In some embodiments, the housing **110** can define a handgrip **116** configured to enable a user to readily grip the conduit bender **100** for ease in maneuverability and use. In one embodiment, the housing **110** can include a leveling device **118** (as depicted in **2**D), configured to serve as an aid in leveling the conduit bender **100** relative to a gravitational frame of reference along at least one of an x-axis and y-axis. For example, in one embodiment, the leveling device **118** can be a bubble level, such as a bull's-eye bubble level, or some other type of leveling tool, such as a magnetic level. In some embodiments, the leveling device **118** can be included within a display **120**/keypad **122**, which in some embodiments can be incorporated into the housing **110**.

FIG. **3**A depicts a conduit bender **100** optionally coupled to a remote user interface **104**, in accordance with an embodiment of the disclosure. FIG. **3**B depicts a conduit bender **100**, with the optional remote user interface **104** selectively removed. In some embodiments, the housing **110** can define one or more electrical connectors **124** (as depicted in FIG. **2**B) configured to enable coupling of a user interface **104**, such as a foot switch (as depicted in FIG. **3**A) or mobile computing device (e.g., a cellular phone or tablet, as depicted in FIG. **10**) to the conduit bender **100**. In other embodiments, one or more external or remote user interfaces **104** can communicate with the conduit bender **100** via a wireless connection.

With continued reference to FIGS. **1-3**B, in one embodiment, the motor **106** can be fixedly coupled to the housing **110** within the interior cavity **112**. In some embodiments, the motor **106** can be powered by a battery pack **126**, which can be removable and rechargeable. In some embodiments, the motor **106** can be electrically (e.g., AC or DC power), pneumatically, or hydraulically operated. The motor **106** can be configured to rotate a driven shaft **128** at a first rotational output. The motor **106** can be controlled via a plurality of inputs. For example, in one embodiment, the first rotational output can be started, stopped and otherwise controlled for speed, duration or both speed and duration via a trigger **130** (as depicted in FIG. **2**A) or other input, for example, mounted within the handgrip **116** of the housing **110**. In other embodiments, actuation of the motor **106** can be controlled via another user input, such as a foot switch **104** (as depicted in FIG. **3**A). Forward and reverse directional control of the first rotational output can be controlled via a forward and reverse switch **132** (as depicted in FIG. **2**A), which can optionally be mounted in proximity to the handgrip **116** of the housing **110**. In other embodiments, one or more of actuation, speed, duration, and directional control of the first rotational output can be controlled, at least in part, by a programmable controller.

With specific reference to FIG. **1**, the reductive gear set **108** can be configured to operably couple the driven shaft **128** to an output shaft **134**, thereby reducing the first rotational output of the driven shaft **128** to a second rotational output of the output shaft **134**. The reductive gear set **108** can be made up of a plurality of different gearing types and configurations to achieve the desired reduction in RPM and corresponding increase in torque necessary to bend conduit. For example, in one embodiment, the reductive gear set **108** can include a worm gear **136**, a compound gear **138** (in which a number of gears, such as a first gear **140** and a second gear **142** are fixedly coupled together), and an output gear **144**. In one embodiment, the worm gear **136** can be coupled to the driven shaft **128**, and the output gear **144** can be coupled to the output shaft **134**.

In one embodiment, the reductive gear set **108** can be constructed of a high strength, rigid material, such as steel; although other materials, such as light weight, high-strength alloys and composites are also contemplated. With reference to FIG. **4**, in one non-limiting, exemplary embodiment, the first rotational output of the driven shaft **128** can rotate between a clockwise rotation of about 450 RPM and a counterclockwise rotation of about 450 RPM; although other rotational speeds are also contemplated. The worm gear **136** can be coupled to the driven shaft **128**, so as to rotate at the same speed. The first gear **140** of the compound gear **138**, which can be configured to interface with the worm gear **136**, can include the appropriate number of teeth to reduce the first rotational output by a desired factor (e.g, a factor of ten). For example, in one embodiment, the first gear **140** can include about 100 teeth. Accordingly, the first gear **140** can rotate between a clockwise rotation of about 4.5 RPM and a counterclockwise rotation of about 4.5 RPM. The second gear **142** of the compound gear **138** can be coupled to the first gear **140**, so as to rotate at the same speed. In one embodiment, the second gear **142** can have a fewer number of teeth than the first gear **140**. For example, in one embodiment, the second gear **142** can include about 20 teeth. The output gear **144**, which can be configured to interface with the second gear **142**, can include the appropriate number of teeth to further reduce the rotational speed of the compound gear **138** to the desired second rotational output. For example, in one embodiment, the output gear **144** can include about 90 teeth. Accordingly, the output gear **144** can rotate between a clockwise rotation of about 1 RPM and a counterclockwise rotation of about 1 RPM. The output shaft **134** can be coupled to the output gear **144**, so as to rotate at the same speed. Accordingly, in some embodiments, the reductive gear set **108** can be configured to complete a 90° conduit bend over the course of about 15 seconds of operation; although, other rotational output speeds are also contemplated. For example, in one embodiment, the portable conduit bender **100** can be configured to bend conduit through a range of angles between about 0° and about 180° over a time span of up to about 60 seconds, depending upon the bend angle desired.

With reference to FIG. **5**, an alternative reductive gear set **108'** configuration is contemplated. In this exemplary embodiment, the first rotational output of the driven shaft **128** can be driven by a motor **106** to be rotated at a first rotational output of between a clockwise rotation of about 10,000 RPM and a counterclockwise rotation of about 10,000 RPM; although other rotational speeds are also contemplated. A worm gear **222** can be coupled to the driven shaft **128**, so as to rotate at the same speed. A first gear **224** of a compound gear **226** (in which a first gear **224** can be fixedly coupled to a first bevel gear **228**), which can be configured to interface with the worm gear **222**, can include the appropriate number of teeth to reduce the first rotational output by a desired factor (e.g., a factor of about 100). For example, in one embodiment, the first gear **224** can include about 100 teeth. Accordingly, the first gear **224** can rotate between a clockwise rotation of about 100 RPM and a counterclockwise rotation of about 100 RPM. A first bevel gear **228** of the compound gear **226** can be coupled to the first gear **224**, so as to rotate at the same speed. In one embodiment, the first bevel gear **228** can have a fewer number of teeth than the first gear **224**. For example, in one embodiment, the first bevel gear **228** can include about 20 teeth. A second bevel gear **230** can be configured to interface with the first bevel gear **228**. In one embodiment, the second bevel gear **230** can include the same number of teeth as the first bevel gear **228**, such that the first bevel gear **228** and the second bevel gear **230** rotate at the same speed. A second worm gear **232** can be coupled to the second bevel gear **230**, so as to rotate at the same speed as the second worm gear **232**. An output gear **234**, which can be configured to interface with the second worm gear **232**, can include the appropriate number of teeth to further reduce the rotational speed to the second rotational output. For example, in one embodiment, the output gear **234** can include about 100 teeth. Accordingly, the output gear **234** can rotate between a clockwise rotation of about 1 RPM and a counterclockwise rotation of about 1 RPM. The output shaft **134** can be coupled to the output gear **234**, so as to rotate at the same speed. Accordingly, in some embodiments, the reductive gear set **108'** can be configured to complete a 90° conduit bend over the course of about 15 seconds of operation; although other rotational output speeds are also contemplated.

With reference to FIGS. **3**A and **6**A-B, one or more bender shoes **102** can be selectively coupled to the output shaft **134** to rotate across a range of motion necessary to complete desired conduit bends. As depicted in FIG. **3**A, in one embodiment, the bender shoe **102** can define an arcuate channel **146** along a peripheral edge **148** of the bender shoe **102**, shaped and sized to receive a cross-section of conduit of a standard trade size. The arcuate channel **146** can define a convex arc corresponding to the NEC approved a minimum bend radius for conduit of a standard trade size. Accordingly, in one embodiment, the size of the bender shoe **102** can be specific to the size of the conduit to be bent. Different sized bender shoes **102** can be provided for different sized conduit. For example, a first bender shoe can be provided for ½ inch EMT, an optional second bender shoe can be provided for three-quarter inch EMT, and optional third and fourth bender shoes can be provided for 1 and 1¼ inch EMT. In other embodiments, a combination bender shoe (not depicted) defining a plurality of arcuate channels shaped and sized to receive the different diameter conduit sizes can be provided. In some embodiments, the bending shoe **102** can be configured to bend other materials, such as Rigid Metal Conduit (RMC), Intermediate Metal Conduit (IMC), copper tubing, tubing used for HVAC or refrigeration systems, tubing used in elevator systems, and other types of tubing or conduit.

The bender shoe **102** can optionally include markings **150**A-C configured to indicate the angular position of the bender shoe **102** relative to other portions of the conduit bender **100**, in particular the housing **110**. For example, the markings **150**A-C can optionally include an arrow (A) to be used with stub, offset and outer marks of saddle bends, a rim notch (N) configured to aid in locating the center of a saddle bend, a star (S) configured to indicate the back of a 90° bend, as well as a degree scale depicting common bending angles relative to the housing **110** (e.g., 10°, 22.5°, 30°, 45°, 60°, etc.) for offset bends and saddles (not depicted).

In one embodiment, the bender shoe **102** can be constructed of a lightweight, rigid material, such as aluminum; although other materials, such as high-strength plastics and composites are also contemplated. In one embodiment, the bender shoe **102** can include a hook **152** configured to engage conduit received within the arcuate channel **146**. In one embodiment, the bender shoe **102** can define a plurality of material cutouts **154**, for example circular throughbores, configured to reduce the overall weight of the bender shoe **102** by removing material unnecessary for support and function.

A connection aperture **156** can be defined in the bender shoe **102** for selective coupling of the bender shoe **102** to the output shaft **134**. In one embodiment, the connection aperture **156** can be configured to match a keyed cross-section of the output shaft **134**. For example, the output shaft **134** can have a substantially square cross-section; although other shaft configurations, such as circular, semicircular, elliptical, triangular, polygonal, splined, or key cross-sections are also contemplated. In one embodiment, the output shaft **134** can include a quick release mechanism **158** configured to enable ease in connection and disconnection of the bender shoe **102** from the output shaft **134**.

For example, with additional reference to FIG. **7**, in one embodiment, the quick release mechanism **158** can include one or more outwardly biased balls **160**A/B configured to interface with one or more corresponding detents **162**A/B defined within the connection aperture **156**. In one embodiment, the one or more balls **160**A/B can be forced into one or more corresponding apertures **164**A/B defined within a tubular wall **166** of the output shaft **134** into a locked position. The one or more balls **160**A/B can be forced into the locked position via a release member **168**, which can be shiftable between the locked position (as depicted in FIG. **7**) and a release position, for example, by pressing on a release surface **172** of the release member **168**. In some embodiments, the release member **168** can be biased to the locked position by a biasing element **174**. In the release position, one or more detents **170**A/B defined by the release member **168** can be positioned in proximity to the one or more balls **160**A/B, thereby enabling the one or more balls **160** to shift inwardly into the one or more detents **170**A/B and out of the one or more apertures **164**A/B, such that the bender shoe **102** can be positioned over the output shaft **134**.

With continued reference to FIGS. **3**A-B and **6**A-B, the conduit bender **100** can further include a bearing wheel assembly **176**. In one embodiment, the bearing wheel assembly **176** can include a bearing wheel **178**. In one embodiment, the bearing wheel **178** can have a substantially circular cross-section, which optionally can define a concave groove **180** (as depicted in FIG. **3**A) shaped and sized to enable a portion of conduit to reside therein and pass therethrough. Other embodiments of the bearing wheel **178** can have an ungrooved surface (as depicted in FIG. **3**B), so as to not limit use of the bearing wheel **178** to any particular conduit diameter or size.

In one embodiment, the bearing wheel assembly **178** can optionally include a mechanism for adjusting a distance of the bearing wheel **178** from the output shaft **134**/bender shoe **102**. For example, with additional reference to FIG. **8**, in some embodiments, a position of the bearing wheel **178** relative to the housing **110** can be adjusted by a driver **182**, such as an electric motor or manual adjustment knob (as depicted in FIG. **2**C). In one embodiment, the driver **182** can be coupled to a first gear **184**, such that the driver **182** and the first gear **184** are configured to rotate at the same speed. The first gear **184** can be configured to interface with one or more second gears **186**A/B, which in turn can be coupled to one or more corresponding threaded rods **188**A/B. The threaded rods **188**A/B can traverse through corresponding threaded bores **190**A/B of a sliding member **192** to which the bearing wheel **178** can be rotationally coupled. In one embodiment, the sliding member **192** can be configured to slide along at least one rail **194**A/B, which can be defined by a portion of the housing **110** within the interior cavity **112**. Various gearing ratios between the first gear **184** and the one or more gears **186**A/B have been contemplated to obtain a desired bearing wheel adjustment actuation speed. Accordingly, in one embodiment, the bearing wheel **178** can be driven to a desired distance from the output shaft **134** or bender shoe **102** to accommodate conduit of varying sizes.

In one embodiment, the housing **110** can include one or more bearing wheel markings **196**A-C configured to aid a user in determining the location of the bearing wheel **178** relative to the output shaft **134**. For example, the bearing wheel markings **196**A-C can include ideal positional indications of the bearing wheel **178** for receipt of ½ inch EMT, ¾ inch EMT, and 1 inch EMT; although other positional markings are also contemplated. In some embodiments, an arrow **198** or other alignment indicator can be present on the sliding member **192**.

In one embodiment, the conduit bender **100** can have angular position sensing capabilities of the rotating components relative to stationary components. In these embodiments, the conduit bender **100** can include an angular position sensor **200** configured to sense rotation of at least one of the driven shaft **128**, components of the reductive gear set **108**, output shaft **134**, or bender shoe **102**, relative to the housing **110**. In one exemplary embodiment depicted in FIGS. **9**A-B, at least a first portion **202** of the sensor **200** can be operably coupled to a portion of the reductive gear set **108**, and can be configured to rotate during operation. A second portion **204** of the sensor **200** can be coupled to a stationary component (e.g., within the interior cavity **112** of the housing **110**). Accordingly, rotation of the first portion **202** relative to the second portion **204** can provide information regarding the angular position of the rotating components relative to the stationary components. In other embodiments, the sensor **200** can be configured to sense rotational movement of the motor **106** or driven shaft **128**.

With continued reference to FIGS. **3**B and **2**D, as well as FIG. **9**, in some embodiments, the conduit bender **100** can include a display **120** configured to display an angular position of rotating components (e.g., the bender shoe **102**) relative to stationary components (e.g., the housing **110**). In some embodiments, the motor **106** can be smart (e.g., programmable), such that a user can input a desired angular position of the bender shoe **102** into a keypad **122** or other user interface (e.g., a smartphone or other mobile computing device) coupled to a programmable controller **206** (as depicted in FIG. **10**), prior to actuating the motor **106** (e.g., via trigger **132** or foot pedal **104**). For example, in one embodiment, a user can utilize a mobile computing device, such as a cellular phone or tablet, in a wired or wireless connection with the programmable controller **206** to transmit information to and receive information from the programmable controller **206**. Upon actuating the motor **106**, the programmable controller **206** can automatically cease operation of the motor **106** upon completing the number of rotations sufficient to reach the desired angular position.

In one embodiment, the bearing wheel driver **182** can be at least partially controlled by the programmable controller **206**. Accordingly, in one embodiment, the display **120**/keypad **122** or other user interface can be configured to accept a desired conduit size, such that during bending operations the programmable controller **206** can automatically drive the bearing wheel **178** to a desired distance from the output shaft **134** via the bearing wheel driver **182** based on the accepted desired conduit size. In one embodiment, the programmable controller **206** can be configured to automatically drive the actuatable bearing wheel **178** from an initial position to a desired distance from the output shaft **134** via the bearing wheel driver **182** to commence bending operations, and return the actuatable bearing wheel **178** to the initial position via the bearing wheel driver **182** upon completion of bending operations. In one embodiment, one or more buttons on the keypad **122** are configured to enable manual adjustment of the bearing wheel driver **182**, which in some embodiments can supplement control of the driver **182** by the programmable controller **206**.

In one embodiment, one or more buttons on the keypad **122** can control a work light **208** (as depicted in FIG. **2**A) configured to illuminate a portion of the conduit in proximity to the bending shoe **102** and bearing wheel **178**. In one embodiment, the display **120**/keypad **122** includes a smart bend angle calculator configured to determine a multiplier to determine spacing of bends, including offset and segmented bends.

Various embodiments of systems, devices, and methods have been described herein. These embodiments are given only by way of example and are not intended to limit the scope of the claimed inventions. It should be appreciated, moreover, that the various features of the embodiments that have been described may be combined in various ways to produce numerous additional embodiments. Moreover, while various materials, dimensions, shapes, configurations and locations, etc. have been described for use with disclosed embodiments, others besides those disclosed may be utilized without exceeding the scope of the claimed inventions.

Persons of ordinary skill in the relevant arts will recognize that the subject matter hereof may comprise fewer features than illustrated in any individual embodiment described above. The embodiments described herein are not meant to be an exhaustive presentation of the ways in which the various features of the subject matter hereof may be combined. Accordingly, the embodiments are not mutually exclusive combinations of features; rather, the various embodiments can comprise a combination of different individual features selected from different individual embodiments, as understood by persons of ordinary skill in the art. Moreover, elements described with respect to one embodiment can be implemented in other embodiments even when not described in such embodiments unless otherwise noted.

Although a dependent claim may refer in the claims to a specific combination with one or more other claims, other embodiments can also include a combination of the dependent claim with the subject matter of each other dependent claim or a combination of one or more features with other dependent or independent claims. Such combinations are proposed herein unless it is stated that a specific combination is not intended.

Any incorporation by reference of documents above is limited such that no subject matter is incorporated that is contrary to the explicit disclosure herein. Any incorporation by reference of documents above is further limited such that no claims included in the documents are incorporated by reference herein. Any incorporation by reference of documents above is yet further limited such that any definitions provided in the documents are not incorporated by reference herein unless expressly included herein.

For purposes of interpreting the claims, it is expressly intended that the provisions of 35 U.S.C. § 112(f) are not to be invoked unless the specific terms “means for” or “step for” are recited in a claim.

What is claimed is:

1. A portable, self-contained tubing bender, comprising:

a motor configured to rotate a driven shaft at a first rotational output;

a reductive gear set operably coupling the driven shaft to an output shaft, the reductive gear set configured to reduce the first rotational output of the driven shaft to a second rotational output of the output shaft;

a housing defining an interior cavity configured to at least partially house the reductive gear set;

a bender shoe coupleable to the output shaft, the bender shoe defining an arcuate channel configured to receive tubing during bending operations;

a sensor configured to sense rotation of at least one of the driven shaft, reductive gear set, output shaft, or bender shoe relative to the housing;

a programmable controller; and

a remote user interface display in wireless communication with the programmable controller configured to transmit one or more desired tubing bend specifications to the programmable controller,

wherein the programmable controller is configured to automatically cease operation of the motor upon reaching the one or more desired tubing bend specifications as determined by the sensor.

2. The portable tubing bender of claim **1**, wherein the arcuate channel of the bender shoe is configured to receive tubing having a diameter of 1-inch or greater.

3. The portable tubing bender of claim **1**, wherein the arcuate channel of the bender shoe is configured to receive at least one of Electrical Metallic Tubing (EMT), Rigid Metal Conduit (RMC), Intermediate Metal Conduit (IMC), copper tubing, stainless steel tubing, tubing used for use in HVAC or refrigeration systems, tubing used in elevator systems, or other types of tubing or conduit.

4. The portable tubing bender of claim **1**, wherein the output shaft includes a quick release configured to enable ease in interchangeability of one or more bender shoes, during a coupling of the one or more bender shoes to the output shaft.

5. The portable tubing bender of claim **1**, wherein the bender shoe is a combination bender shoe defining a plurality of arcuate channels shaped and sized to receive tubing of different diameters.

6. The portable tubing bender of claim **1**, further comprising a bearing member configured to guide and support tubing during bending operations.

7. The portable tubing bender of claim **6**, wherein a position of the bearing member is adjustable relative to the housing.

8. The portable tubing bender of claim **1**, further comprising a built-in level configured to aid in leveling the tubing bender relative to a gravitational frame of reference along at least an x- and y-axis.

9. The portable tubing bender of claim **1**, wherein the motor is battery-powered.

10. The portable tubing bender of claim **1**, wherein the remote user interface is a mobile computing device and the programmable controller is wirelessly couplable to the mobile computing device.

11. The portable tubing bender of claim **1**, further comprising a work light to illuminate the tubing in proximity to the bender shoe.

12. The portable tubing bender of claim **1**, wherein the portable tubing bender is configured to bend the tubing through a range of angles between about 0° and about 180° over a time span of up to 60 seconds.

13. A tubing bender, comprising:

a driver configured to drive a driven shaft;

a reductive gear set operably coupling the driven shaft to an output shaft;

a housing defining a handgrip and an interior cavity configured to house the reductive gear set;

a bender shoe coupleable to the output shaft a sensor configured to sense rotation of at least one of the driven shaft, reductive gear set, output shaft, or bender shoe relative to the housing;

a programmable controller; and

a remote user interface in wireless communication with the programmable controller configured to transmit one or more desired tubing bend specifications to the programmable controller,

wherein the programmable controller is configured to automatically cease operation of the driver upon reaching the one or more desired tubing bend specifications as determined by the sensor.

14. The tubing bender of claim **13**, wherein the bender shoe is configured to receive tubing having a diameter of 1-inch or greater.

15. The tubing bender of claim **13**, wherein the bender shoe is a combination bender shoe defining a plurality of arcuate channels shaped and sized to receive tubing of different diameters.

16. The tubing bender of claim **13**, wherein the driver is battery-powered.

17. The tubing bender of claim **13**, further comprising a member configured to guide and support tubing during bending operations.

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